



Diallo, T., Farhadi Beldachi, A., Muqaddas, A. S., Silva, R., Nejabati, R., Tzanakaki, A., & Simeonidou, D. (2019). Enabling Heterogenous Low Latency and High-bandwidth Virtual Network Services for 5G Utilizing a Flexible Optical Transport Network. In *2019 Optical Fiber Communications Conference and Exhibition, OFC 2019 - Proceedings [W1G.7]* Institute of Electrical and Electronics Engineers (IEEE).
<https://doi.org/10.1364/OFC.2019.W1G.7>

Peer reviewed version

Link to published version (if available):
[10.1364/OFC.2019.W1G.7](https://doi.org/10.1364/OFC.2019.W1G.7)

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Enabling Heterogenous Low Latency and High-bandwidth Virtual Network Services for 5G Utilizing a Flexible Optical Transport Network

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Abstract: For the first time, we demonstrate a 5G network orchestration system supporting low latency and high bandwidth virtual network services over a flexible time slotted optical transport network.

OCIS codes: (060.2330) Fiber Optics Communications; (060.4250) Networks, (060.4253) Networks, circuit-switched

1. Introduction

5G network requirements and Key Performance Indicators (KPIs) are defined in [1]. Among them, the access network should be able to provide a high density of connected devices (1 million connections/km²), high bandwidth, low latency (≤ 1 ms), network slicing and flexibility, scalability and elasticity of the network [1,2]. To achieve the requirements and KPIs, the future optical network for 5G should be flexible, scalable, provide connectivity with low latency and high bandwidth. Time Shared Optical Network (TSON) is a technology, which permits to bring the flexibility and scalability in the optical transport network and offers high bandwidth and low latency connectivity [3] to handle some requirements and KPIs of 5G.

To meet its latency requirements a 5G network requires orchestration of both network functions and connectivity resources. In a 5G network, network functions are often virtualized to run in commodity hardware platform (servers) and are enabled through Network Function Virtualization (NFV). Also, in a 5G network, the preferred method of managing network connectivity is vendor and technology-agnostic, enabled by Software Defined Networking (SDN). Therefore, in 5G network, a Management and Orchestration (MANO) systems is required which can orchestrate both SDN and NFV technologies [4]. MANO systems support the deployment of Virtual Network Services (VNSs), consisting of several chained Virtual Network Functions (VNFs) hosted by compute resources, and interconnected by the network resources. For each VNS, MANO creates a network slice of the end-to-end network, where each VNS may have varying resource requirements. To accommodate a variety of VNSs with different network requirements, TSON is a viable optical transport network candidate due to its flexible nature. TSON consists of transmitting a variable number of TDM frames with variable time slot size over an optical infrastructure. This variable nature of TSON allows the accommodation of network services (VNSs) with different granularity of data rates. Thus, throughput and the latency in the TSON network is variable, hence scalability and flexibility in the optical transport network can be achieved by this technology.

In this paper, we demonstrate for the first time TSON with the NFV orchestration, where the latter is responsible for managing and deploying VNFs of a VNS in multiple compute nodes. The underlying connectivity between the compute nodes is enabled by TSON. We show that TSON can support heterogenous virtual network services, and network slicing using orchestration in the optical transport network. We briefly discuss the architecture of TSON, followed by the TSON testbed utilized in our experiment.

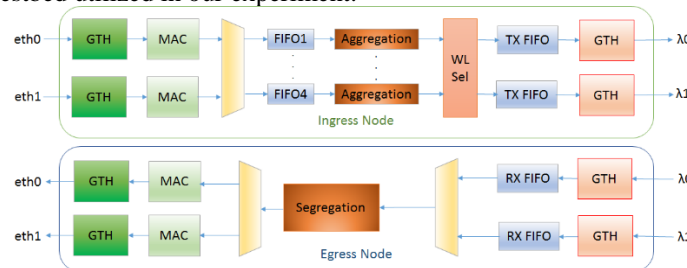


Fig. 1. TSON architecture in the FPGA [3]

Since the TSON latency depends on the size of packets (64 bytes or 1500 bytes), the number of the time slices (TS), the data throughput (relative to the size of the TSON frame) and of the interleaved distribution of the TS [7,8], an empirical model to evaluate the latency has been built (Fig. 3) to provide the weight of the TSON edge nodes used to

perform the shortest path algorithm. For a given data rate, to minimize the latency, a continuous distribution with 62 time slices has been considered [7,8]. Furthermore, to estimate the latency in real transmission, the size of the generated packets to build this empirical model is randomly selected between 64 bytes and 1500 bytes. To evaluate the performance of data plane, the LTE VNS is deployed from OSM which has a 1Gb/s bandwidth, 360 μ s latency and VLAN ID 100 where the input TSON port is 1. The second VNS for “iperf” has 1 Gb/s bandwidth, 500 μ s latency and VLAN ID 101 where the input TSON port is 2. 2 km of optical fiber is allocated to the LTE VNS and 8 km of optical fiber is allocated to iperf VNS. Also, the UE in the LTE network service uses iperf tool to measure the performance of the mobile backhaul network based on TSON.

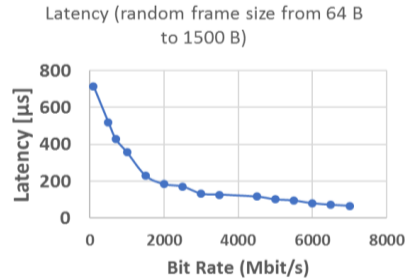


Fig. 3. Latency result using by the TPC

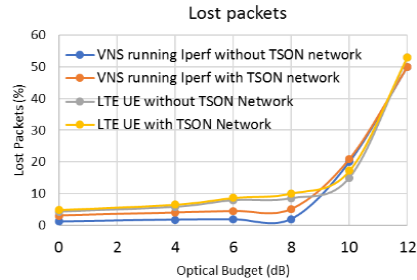


Fig. 4. End-to-end lost packets

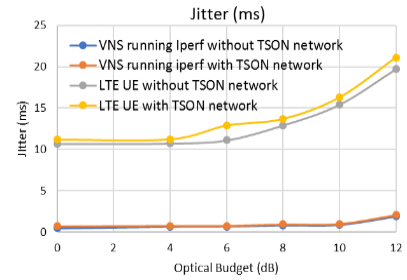


Fig. 5. End-to-end lost jitter

3. Data plane performance result

To show the impact of TSON, the result for the case without TSON where the two ends of the datacenters are connected only via OXC is also computed and compared with the case where TSON is used. Figs. 4 and 5 show the performance of the data plane vs. the optical budget about the lost packets and jitter respectively. The average of the difference between the result of with and without using TSON is about 2% for the “iperf” VNS and about 1.1% for the LTE VNS for the lost packets. The average of the difference in case of jitter is about 0.1 ms for the “iperf” VNS and about 0.9 ms for the LTE VNS. This slight increment of the lost packet and jitter is due to the data processing performed by the FPGA.

Also, the radio performance is measured by connecting the Radio Frequency (RF) output port of the USRP to an LTE spectrum analyzer. The TSON network does not have any influence on the quality of the radio signal. Indeed, for an LTE Bandwidth of 10 MHz the data transmission rate is constant and equal to 12 Mbit/s for the UE. In addition, the Error Vector magnitude (EVM) is 1.2 % on the RF downlink and 1.8 % on the RF uplink.

4. Conclusion

In this paper, we demonstrate for the first time, the orchestration of heterogenous virtual network services over a TSON. The different interfaces between the OSM and TSON SDN controller, and between the TSON SDN controller and the data plane elements are discussed. The TSON path computation based on an empirical method to estimate the latency has been developed. The presented architecture brings flexibility and scalability by reconfiguring the TDM features of TSON via the implemented SDN controller which includes the extended OpenFlow protocol in order to control the data plane. Network slicing is enabled for various network services by classifying the traffic based on VLAN tag. In addition, the TSON does not have any impact in the performance on the RAN and does not introduce much latency and jitter in the optical transmission.

5. Acknowledgment

This work has been supported by EU H2020 5G-PICTURE and Metro-Haul (grant agreements 762057, 7617727), and EP/L020009/1 “TOUCAN”.

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